DESIGN AND DEVELOPMENT OF TEXTURE CLASSIFICATION ALGORITHMS BASED ON LOCAL BINARY PATTERN

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Abstract-- Local binary pattern is very effective frameworks for capturing texture feature from image. It is widely used for texture classification of grayscale image because of its computational simplicity. But it has poor performance in texture classification of color image. It also has some other drawback like limited discrimination capability, noise sensitivity and high dimensionality. To overcome these drawbacks, we proposed method based on local binary pattern for texture classification of color image. It also has high discrimination capability, low dimensionality and robust to noise sensitivity. The proposed method is tested against different classification challenges such as scale, rotation and illumination. In this work Color histogram, color difference histogram and support vector machine will be used to increase the performance of proposed texture classification method. An experiment will be conducted on standard database called Brodatz, Colored Brodatz, OUTEX and TH-TIPS2 to show the performance of proposed method.

1. INTRODUCTION

Texture feature play an important role in texture classification method. There are lots of texture classification methods developed by researcher works only on grayscale images and it has poor performance in describing texture pattern of color image. This can motivate researcher to develop efficient texture classification method for color image. Texture can be defined as visual surface of object or image. It contains information about structural arrangement of surface and relationship to the surrounding environment [1]. According to Webster's dictionary texture is defined as "the character of a surface as determined by the arrangement, size, quality and so on." Texture feature is used in many different problems like texture segmentation, texture synthesis and texture classification etc. Among these problems we will focus on texture classification problem to develop efficient texture classification method that describe texture pattern of color image and works well under a verity of texture classification challenges such as scale, rotation and illumination.

Texture classification can be defined as, it is the process of classifying texture pattern of given image. Application area of texture classification includes industrial inspection, remote sensing, medical imaging and document analysis. Various texture classification method developed by researcher during last two decades. Examples of most commonly used texture classification method are: Grey level co-occurrence matrices, Gabor Filter, Local binary

pattern, Scale invariant feature transform, Speed up robust feature, Texture spectrum. Among these methods we focused on Local binary patterns (LBP) method because of their simplicity, good performance in texture classification and robustness in representing local features of image. The LBP method and its variant describe only texture pattern of grayscale image. It has some drawbacks like poor performance in describing texture pattern of color image, high dimensionality, limited discrimination capability and noise sensitive [2].

In this research work we will study all drawbacks of LBP method and will propose texture classification method based on LBP that describes texture pattern of color image. It also has high discrimination capability, low dimensionality and robust to noise. In this research work we will also use Color histogram (CH) method, Color difference histogram (COD) method with Support vector machine (SVM) to increase the performance of proposed texture classification method. Rest of the synopsis is organized as follows:

We present related work of texture classification methods in section 2. Significance of research is presented in section 3. Section 4 shows the objective of research work. Methodology used to develop texture classification method is given in section 5. Detail of standard database used for experimental work is given in section 6. Importance of study and international/national status of study is given in section 7. Year wise plane of work and target to be achieved is given in section 8.

2. LITERATURE REVIEW

There are various methods developed by researcher for texture classification. In this section we review on some of the important texture classification method.

Bachir Kaddar et. al. [3] has reported that, texture feature based on local binary pattern. In this work robust discriminating texture feature are proposed called ELBP. It considers spatial information within image. It achieves good performance in term of segmentation accuracy and robustness to noise. The method uses an automatic and efficient determination of threshold to compute the LBP code. The experiment is conducted on standard image database. The result shows that, the potential of ELBP to improve the texture discrimination ability.

Chandan Singh et. al. [4] has proposed enhancing color image retrieval performance with feature fusion and non-linear support vector machine classifier. In this work a fusion of color

histogram (CH), orthogonal combination of LBP and Color difference histogram features are used to capture color, texture and shape feature of image. The proposed fusion approach is compared with individual and other fused features. The experiment result shows that fused features using SVM classifier gives the best result for all standard database used for experimental work.

Davar Giveki et. al. [5] has proposed a new image descriptor for content based image retrieval using Scale invariant feature transform and local derivative pattern. In this work novel image descriptor is introduced using SIFT and LDP that is able to find similarity and matches between images. The proposed descriptor produces high discriminative feature for describing image content. These features are used to achieve higher level of semantics. The proposed method is evaluated using different image database.

Chandan Singh et. al. [6] has reported that color texture description with novel binary pattern for effective image retrieval. In this work novel local color texture descriptor proposed called Local binary pattern for color image (LBPC). It describe texture pattern of color image to boost the discriminative power of proposed LBPC operator. Hue component in HIS color space is used with proposed texture descriptor called LBPH. Further LBPC, LBPH combined with color histogram called CH to form an effective image retrieval method LBPC+LBPH+CH. The uniform patterns of two proposed descriptor are combined to yield another low dimension local color descriptor called ULBPC+ULBPH+CH which provide good retrieval accuracy and speed.

Subrahmanyam Murala et. al. [7] has proposed expert content based image retrieval system using robust local patterns. In this work robust LBP operator is used to describe texture feature of local reason in an image. Furthermore, the combination of Gabor transform and RLBP operator are performed to develop robust method called GR-LBP. To test the performance of proposed method the experiment is conducted on different image database namely, Corel, Brodatz and MIT VisTex database under different illumination and noise conditions.

Zhenhua Guo et. al. [8] has proposed rotation invariant texture classification method using Local Binary Pattern (LBP). In which global matching scheme use LBP for feature extraction. The extracted LBP features can be used to estimate the principal orientations of image. In this paper author also proposed a new operator called Local Binary Pattern

Variance (LBPV). It computes the variance (VAR) from local region and accumulates it into the LBP bin. The LBPV operator could reduce the requirement for the dependency on a large number of training samples. The experiment was conducted on Outex database and CURet database. From experiment result author concluded that, global rotation invariant matching scheme with rotation variant LBP or LBPV features leads to much higher classification accuracy than traditional rotation invariant LBP.

Sudhir P. Vegad et. al. [9] has proposed hybrid approach. In this approach global image property and neural network are used for classification of image. It provides effective and efficient image retrieval system. The experiment work is carried out using fruit image database. From the experiment result author conclude that, use of neural network improve recall rate and retrieval time. The use of back propagation algorithm also increase precision rate due to its capability of minimizing the error during training process. The result may be affected if the images of same fruit taken for training are having less global similarity.

Baofeng Zhang et. al. [10] has proposed efficient image matching algorithm based on SURF algorithm. This approach can be generally divided into four steps. 1) Feature points are extracted by SURF algorithm and feature descriptor is determined by Haar wavelet, 2) image matching point pairs are obtained using nearest neighbor matching algorithm, 3) the false matches and wrong match point are eliminated by Random Sample Consensus (RANSAC) algorithm and 4) the matching results are obtained by the experiment. From the experiment result author concluded that, the algorithm has high accuracy of image matching. In addition to this, the algorithm is robust and image matching speed is very fast.

Leila Kabbai et. al. [11] has proposed image matching based on LBP & SIFT descriptor. In this work author use a new descriptor for extracting invariant feature from interest region. New descriptor are SNL, SNCS and NLCS generated using combination of SIFT and LBP descriptor. These descriptors are used to improve the matching result. The experiment was conducted on MARS & SIMPLICITY database. Different evaluation measures are used such as repeatability, recall and precision for various image transformations. From the experiment result author concludes that new descriptor gives better result than SIFT descriptor.

Xiaoli Yuan et. al. [12] has reported that, a SIFT-LBP image retrieval model based on bag of features. In this work author was proposed a novel image retrieval system based on bag of features (BOF) model. SIFT and LBP features yield complementary and substantial

improvement on image retrieval even in case of noisy background and ambiguous objects. These SIFT and LBP features are integrated in two levels called patch level and image level. Database used in this work are Corel database. From the experiment result author conclude that image level model give better result as compare to patch level model.

Jeyabharathi D. et. al. [13] has reported that, performance analysis of feature extraction and classification technique in CBIR system. In this work author was examined feature extraction technique like, principal component analysis (PCA), linear discriminate analysis (LDA), and independent component analysis (ICA) with support vector machine (SVM) and Nearest Neighbor (NN) classifier. From the result author concluded that, PCA with SVM classifier performs better than the other two methods. The combination of three feature extraction algorithm with SVM classifier produced more accurate result than NN classifier.

Katta sugamya et. al. [14] has reported that, comparative study of different feature extraction method and the various similarity metrics. In this work author proposed CBIR system to overcome the problem of textual approach. It use visual features of image and combined these features effectively. So that, the retrieval accuracy and recall rate is enhanced. The classification technique such as, SVM are used to classify the features of image. SVM classifies the relevant and non relevant images from image database based on query image. It improves the accuracy of CBIR system. The experiment was conducted on sample image database. From the experiment result author concluded that, using SVM classifier accuracy and error rate of CBIR system is found to be precise. This method gives much better performance than the traditional method of image retrieval.

3. SIGNIFICANCY OF RESEARCH

Texture classification has significant impact in the field of computer vision and pattern recognition. In this research work we focused on local binary pattern (LBP) to develop texture classification method. Many researchers express their view on the capability of LBP in terms of image classification, analysis and recognition. Researchers working on local binary pattern in different domain have some views like, poor performance in describing texture pattern of color image, high dimensionality, limited discrimination capability and noise sensitive. This research works over comes these LBP drawbacks.

- The purpose of this research work is to develop robust texture classification method based on local binary pattern.
- This research work supports the researcher to develop different texture classification method that has high resulting accuracy and low time complexity.
- This research work also help for other researcher who will be interested in doing advanced research on the same topic and this will be beneficial for research community in the field of image processing.

4. OBJECTIVE OF RESEARCH

The main objective of this research work is to develop efficient texture classification method base on LBP that has low dimensionality, high discrimination capability, robust to noise sensitive and describing texture pattern of color image. The main objective of this research work can be used to achieve following sub-objective:

- To develop texture classification method that classifies and recognize texture pattern of image.
- To develop texture classification method that is robust to different classification challenges such as scale, rotation and illumination.
- To develop texture classification method that precisely and accurately represents texture feature of image.
- To compare the performance of proposed texture classification method with different texture classification method.
- To test the performance of proposed texture classification method individually using support vector machine.
- To test the performance of proposed texture classification method using combination of color histogram method and color difference histogram method with support vector machine.

5. PROPOSED METHODOLOGY

Local binary pattern (LBP) is one of the highly demanded features for texture image retrieval and classification task because the combination of LBP with other features yields a good result in various applications as reported in literature review. LBP descriptor developed

originally for representing texture feature of gray scale image. It has some drawback like poor performance in describing texture pattern of color image, high dimensionality, limited discrimination capability and noise sensitivity. This research work overcomes these LBP drawbacks.

In this research work we proposed texture classification method based on LBP descriptor. The Color histogram (CH), color difference histogram (CDH) and Support vector machine (SVM) is used to increase the performance of proposed texture classification method. Schematic diagram of proposed texture classification method is given below.

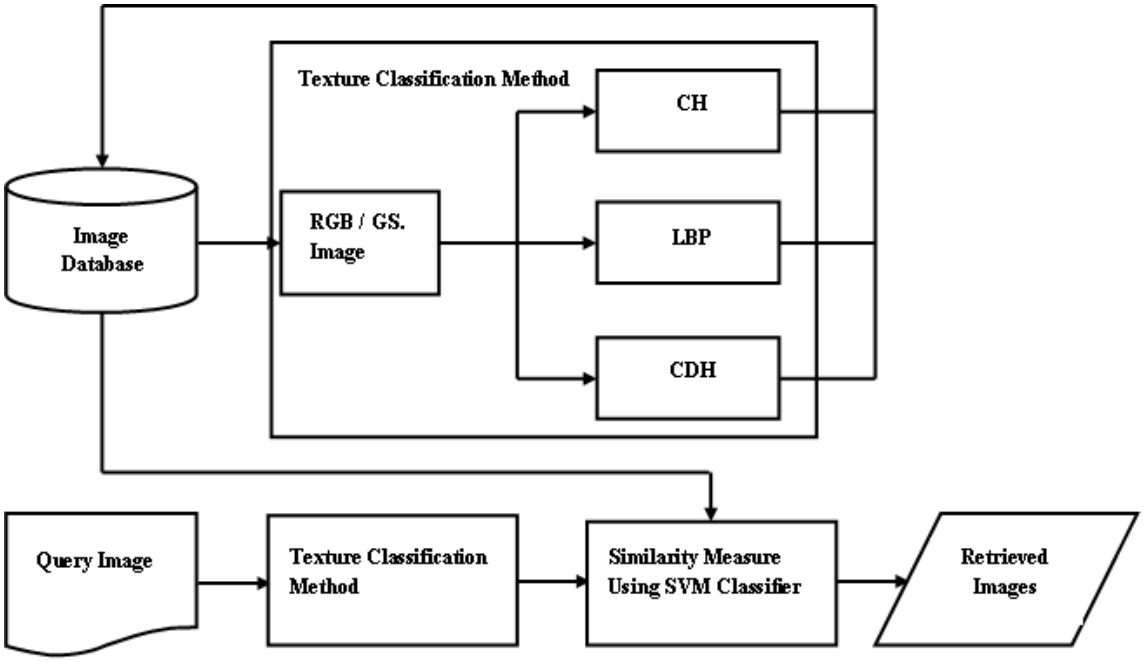

Fig.1. Schematic diagram of proposed texture classification method

In above diagram all images in image database and input query image are passed to texture classification method. It extracts features like CH, LBP and CDH from the input query image and database images for texture classification of image. Feature vector of all images in image database is computed and stored into database. To measure similarity between feature vector of query image and feature vector of database images similarity measure module use support vector machine (SVM). Then the most similar images are retrieved from image database and display on the screen. Detail of methodology used to develop texture classification method is given below.

5.2 Local Binary Pattern (LBP)

Local binary pattern is generic texture descriptor introduced by Ojala et. al.[15]. It is widely used for texture classification of grayscale image. LBP describes the eight neighborhood pixels in binary code and summaries all code into histogram which serve as texture feature. In simple word LBP label each pixel of an image with decimal number called local binary pattern or LBP code. Following figure shows the example of basic LBP descriptor.

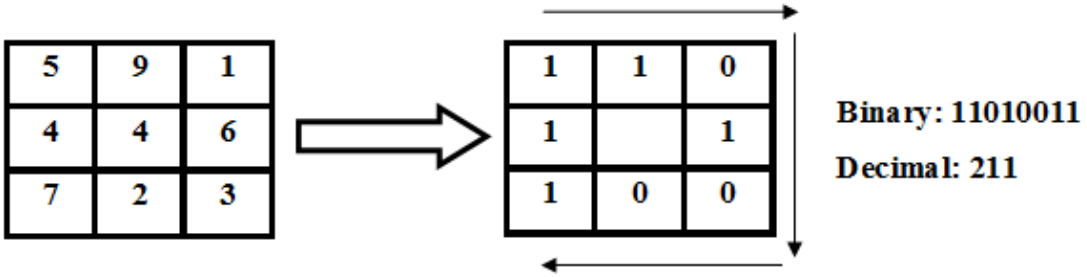

Figure 2: An example of the basic LBP

As shown in above figure each pixel is compared with its eight neighbors. The center pixel value is subtracting from its neighboring pixel value. The resulting negative values are encoded with 0 and other with 1. A binary number is obtained by concatenating all these binary codes in a clockwise direction starting from the top-left one and its corresponding decimal value is used for labeling. LBP variants for texture classification are (basic) Local Binary Patterns, rotation invariant LBP, Uniform LBP, Multi-dimensional LBP, LBP variance (LBPV), Adaptive LBP (A-LBP), Multi-Scale spatial pyramid LBP (MSSP-LBP), Pyramid LBP (P-LBP), and Completed LBP (C-LBP) [16].

To overcome the drawbacks of LBP we proposed texture classification method. It solves all the issue related to LBP method. Brief description of LBP drawbacks are given below.

- LBP has High dimensionality issue leads to difficulties in computation and classification performance. Dimensionality of LBP method is increased by increasing number of neighboring pixel. To decrease the dimensionality we need to restrict number of neighboring pixels of central pixel.
- LBP method has serious weakness of noise sensitivity for local pixel based texture feature. It means slight changes to gray level value of central pixel or neighboring pixel can change the whole LBP pattern. In other word noise may change uniform pattern into

unstable non-uniform pattern. So we need to find a mechanism to recover uniform pattern.

- LBP has poor performance on describing the texture pattern of color image or it is less suitable for measuring the similarity of color image. To solve this problem we add color feature with LBP feature or consider each channel of color image as a gray scale image and compute LBP code for each channel.
- LBP has limited capability to capture discrimination information because sign of difference vector is used to represent local region of image, the magnitude of difference vector also contain discrimination information is completed discarded. As a result local reason of image with different gray level value may have same LBP code and lead to misclassification of different texture patterns. Sign and magnitude component of difference vector represent difference of neighboring pixel against central pixel. To increase discrimination power of LBP we need to combine these sign and magnitude component of difference vector.

5.2 Color Histogram (CH)

Color Histogram is widely used technique for extracting color feature of image. It represents the frequency distribution of color bins in an image [17]. In other word color histogram is a representation of color distribution in an image. There are two types of color histogram global color histogram and local color histogram. Global Color histogram analyzes color frequency in whole image. It is used to solve the problems like change in translation, rotation and angle of view. Local color histogram focuses on the individual parts of an image. It considers the spatial distribution of pixel which is lost in global color histograms. Color histogram is easy to compute as compared to other methods and invariant to image size, orientation. Apart from these advantages, it faces two major drawbacks. First, overall spatial information is not taken into account. Second is that the histogram is not robust and unique for two different images with same color. Color histogram features are obtained in color space. There are three main color spaces which are normally used for color image processing task: RGB, HSV and $L^*a^*b^*$. Among these three color space we use one of the color space for experimental study. In this research work color histogram is used with proposed texture classification method to extract color feature from image.

5.3 Color difference histogram (CDH)

Liu and yang (2013) has proposed the concept of color difference histogram to encode the visual appearance of the image. It works as feature descriptor of image and analogous to human visual system. CDH is very sensitive to color and edge orientation present in digital image. The unique characteristic of CDH is that, it counts the perceptually uniform color difference between two pixels under different background with color and edge orientation for image representation [4]. In simple word it describes both color difference and edge orientation feature of digital image. Color space is used to extract CDH feature from image. Color space may be DKL, RGB, LMS, HSV, $L^*a^*b^*$ etc. The color difference histogram approach encodes color difference in two vectors: $H_{color}(x, y)$ and $H_{orient}(x, y)$. The first vector $H_{color}(x,y)$ represent the perceptually uniform color difference between neighboring edge orientation. The second vector H_{orient} (x, y) represents the perceptually uniform color difference between neighboring color indexes. The two vectors $H_{color}(x, y)$ & $H_{orient}(x, y)$ are concatenated to form a single vector H_{CDH} called color difference histogram.

The following points illustrate the method of plotting color difference histogram.

- Convert the image from RGB to different color space like $L^*a^*b^*$.
- Compute edge quantization in $L^*a^*b^*$ space.
- Compute color quantization in $L^*a^*b^*$ space.
- Compute feature vector from the result in step 2 and 3.
- Plot the histogram.

In this research work color difference histogram is used with proposed texture classification method to extract color and edge orientation feature from image.

5.4 Support Vector Machine (SVM)

Support vector machine was first proposed by vapnik and it is gaining popularity in the field of machine learning [14]. SVM also called support vector network. It is supervised learning algorithm that analyzes data used for both classification and regression. However, it is used in texture classification problems because it provides superior result as compare to other classification method. It has wide range of application like handwritten character recognition, image classification, face detection, bioinformatics, medical diagnostics and data mining.

SVM are based on the concept of decision planes that defines decision boundaries. A decision plane is one that separates a set of objects having different class memberships. In simple word a support vector machine is a discriminative classifier formally defined by a separating hyper plane. For example, a linearly separable set of 2d-points which belong to one of two classes.

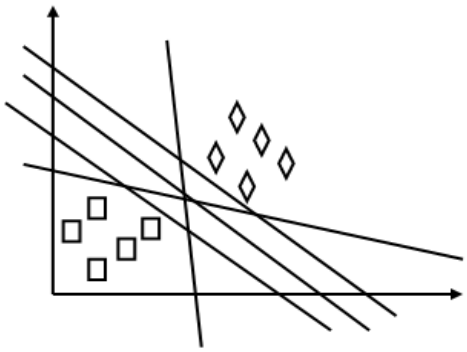

Figure 5: Linearly Separable Set of 2D-Points.

Above figure shows that, there exists multiple lines that offer a solution to the problem. A line is bad if it passes too close to the points because it will be noise sensitive. It will not generalize correctly therefore, to find the lines passing as far as possible from all points. The operation of SVM algorithm is based on finding the hyper plane that gives the largest minimum distance to the training examples. In this research work we use support vector machine to boost the performance of proposed texture classification method and to measure the similarity between images.

6. DATABASE

- **BRODATZ TEXTURE DATABASE**

To test the discrimination ability of proposed method regarding different texture pattern size Brodatz texture database is used. It contains grayscale texture images in TIFF format. All the images in this database can have unique texture pattern. It contains 13 classes of texture image where each class contains 7 images. Each and every image in this class is rotated in seven different angles 0^o, 30^o, 60^o, 90^o, 120^o, 150^o, 200^o. The size of all images in this database are 512×512 and stored 8 bit data per pixel. Database contain total $13 \times 7=91$ images [18].

- **COLORED BRODATZ TEXTURE DATABASE**

To test the performance of proposed method against color image we use Colored Brodatz Texture (CBT) database. It is an extension of the Brodatz texture database from grayscale to color images. This new database has the advantages of preserving the rich textural content of the original Brodatz database and also having a wide variety of color content [19].

- **KTH-TIPS2**

To test the robustness of proposed method against noise condition we use KTH-TIPS2 database. It contains images of different imaging condition include change in scale, illumination and pose conditions. There are two version of KTH-TIPS2 exist. These are KTH-TIPS2-a & KTH-TIPS2-b. KTH-TIPS2-a does not contain equal number of images for each sample (40 out of 44 sample have 108 images, but 4 sample contains only 72 images). KTH-TIPS2-b contains 108 images for all 44 samples [20].

- **OUTEX**

To test the performance of proposed method against different scale, rotation and illumination condition we use OUTEX database. It includes two test suits: Outex_TC10 and Outex_TC12. Both contain 24 classes of images with 20 sample per class captured under three illumination ("inca", "t184", "horizon") and nine rotation angle (0, 5, 10, 15, 30, 45, 60, 75 and 90). Most OUTEX test suite contains 24 classes of images yields very high classification result [21].

7. IMPORTANCE OF STUDY

Recent advances in digital imaging technology, it possible to capture, manipulate, store, and transmit images at interactive speeds. As a result, images have become a dominant part of information exchange. They are used for entertainment, education, commerce, science, and other applications. The rapid collection of digital images has created the need for classification method. Nowadays there has been a great interest in the development of texture Classification methods in many different areas. The applications areas of texture classification include industrial inspection, remote sensing, medical imaging, document analysis, etc. [22].

- Industrial inspection

In industrial processes, the detection of defects in manufactured products or in the raw material is important part. Manual visual inspection is often a tedious and laborious task. Hence, texture classification plays an important role in inspection. There are numerous approaches to industrial inspection by texture classification. Two examples are quality inspection of painted metallic surfaces and lumber defect detection.

- Remote sensing

Remote sensing means scanning of earth by satellite. It includes satellite photography, satellite multi-spectral measurements, seismic surveys, sonar surveys etc. Numerous approaches to texture classification in remote sensing have been presented. It includes terrain classification, cloud classification, seaport mapping, and seismic pattern recognition.

- Medical imaging

Images in this field arise from different techniques as photography, x-ray, ultrasound, tomography etc. In these types of images, textural classification technique is important for diagnosis. Cancer is often characterized by textures with different medical imaging techniques. Breast cancer is a leading cause of cancer deaths among women. Early detection is the most effective way to reduce mortality, and mammographic screening is currently the best method for early detection. Texture classification technique has been applied successfully to the detection of lesions in mammographic images. In this field texture classification technique is also successfully used for cancer detection.

- Document image analysis

It is one of the useful applications of machine vision and image analysis. Texture classification method is used in document image analysis for character recognition. Document image analysis has application ranging from postal address recognition to analysis and interpretation of map. In many postal documents processing application the first step is the ability to separate the regions in the image, which contains useful information. The texture classification method is used for recognition of destination address and zip code on envelopes.

7.1 International and National Status of Study

At present, texture classification method has many encouraging research progress, we still need to carryout research on texture classification method to get better result. Although the researcher has developed many texture classification methods such as, GLCM, SIFT, SURF, TS and Gabor Filters. But only certain level these methods works well only for grayscale image. Therefore further studies are needed to estimate the instability factor and make more robust method for texture classification. Some examples of texture classification methods are given below.

- **Grey Level Co-occurrence Matrices (GLCM)**

GLCM is popular texture feature extraction method widely used in many image processing applications. It is a statistical method proposed by Haralick in 1973 to extract second order statistics texture feature from image. GLCM computes the relationship between pixel pairs in an image [23]. It is also known as the gray-level spatial dependence matrix. Textural features calculated from GLCM include contrast, correlation, energy, entropy and homogeneity. The GLCM can also be applied on different color space for color co-occurrence matrix.

- **Gabor Filters**

Dennis Gabor proposed Gabor filter is popular signal processing method. It is also known as Gabor wavelets represent signals in both times as well as frequency domain [23]. The Gabor Filter defined by parameters like frequency, orientation and standard deviation. It is a linear filter used for texture analysis. That means it analyses whether there is any specific frequency content in specific directions or region of image. Gabor filter is also used for line detection, finding orientation of an image.

- **Scale Invariant Feature Transform (SIFT)**

SIFT feature is used to detect and describe local features in image. The SIFT feature was published by David Lowe in 1999. Matching features across different images is a common problem in computer vision. SIFT image features provide a set of features of an object that are not affected by object rotation, change in scale and illumination [24]. When all images are similar in nature (same scale, orientation, etc.) simple corner detectors can work but when you have images of different scales and rotations, you need to use the scale invariant feature transform. The scale invariant feature transform (SIFT) bundles feature detector and feature descriptor. The detector extracts a number of frames from image in such a way that, it is

consistent with some variations of illumination, viewpoint and other viewing conditions. The descriptor associated to the regions of image which identifies their appearance compactly and robustly. Application of SIFT include object recognition, image stitching, 3d modeling, gesture recognition, video tracking etc.

- **Speed up Robust Feature (SURF)**

Speed up Robust Feature is a local feature descriptor proposed in 2006 [10]. It is a common object detecting and object-matching feature in image processing. SURF feature can be used for object recognition, image classification, image retrieval or 3D reconstruction. It is partially inspired by the scale-invariant feature transform (SIFT) descriptor. SURF is local feature descriptors extracted at interest points in an image. It is invariant to scale, rotation and illumination variation of image. This descriptor can be used to detect extent of matching between two images or detection of a particular object in an image. Repeatability, distinctiveness and robustness are outstanding characteristics of SURF. It is used to select the interest point at distinctive location in image such as, corners, blobs and T-junctions. Calculation speed and matching rate of SURF feature is very high.

- **Texture Spectrum (TS)**

Texture image can be decomposed into set of essential small unit called texture unit [25]. Texture spectrum approach is based on texture units, which characterize local texture information in all eight directions. This method has been applied to texture feature extraction, texture classification, edge detection and texture filtering. One of the advantages of texture spectrum approach is that, the texture aspects of an image are characterized by the corresponding texture spectrum. Texture spectrum can be directly used for image classification and image analysis. The basic principles used for estimating the texture spectrum (TS) including the texture unit (TU) and the texture unit number (N_{TU}).

8. YEAR WISE PLANE OF WORK AND TARGETS TO BE ACHIEVED

Sr. No.	Research Activity	Time Required
1.	Review of Literature	06 Months
2.	Research methodology adopted	08 Months
	Finalization of objective	
	Data collection	
	Data processing	
3.	Implementation of algorithms	06 Months
4.	Testing of Algorithm	02 Months
5.	Paper publication in standard journal or International/ National Conference	04 Months
6.	Thesis writing	06 Months
7.	Thesis Submission	04 Months

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